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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/072,164	02/07/2002	Mira Ben-Tzur	10002.000400 (PM01045)	1254
31894	7590	02/25/2005	EXAMINER	
OKAMOTO & BENEDICTO, LLP			MANDALA, VICTOR A	
P.O. BOX 641330			ART UNIT	
SAN JOSE, CA 95164			PAPER NUMBER	
			2826	

DATE MAILED: 02/25/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

CT

<b>Office Action Summary</b>	<b>Application No.</b> 10/072,164	<b>Applicant(s)</b> BEN-TZUR ET AL.	
	<b>Examiner</b> Victor A. Mandala Jr.	<b>Art Unit</b> 2826	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 18 November 2004.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-11 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-11 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |   |   |
|---|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)   | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)  | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152)             |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)<br>Paper No(s)/Mail Date <u>11/18/04</u> . | 6) <input type="checkbox"/> Other: _____  |

## DETAILED ACTION

### *Claim Rejections - 35 USC § 102*

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1-6, 8, & 9 are rejected under 35 U.S.C. 102(e) as being anticipated by U.S.

Patent Application Publication No. 2002/0047172 Reid.

1. Referring to claim 1, a method of forming an interconnect line in an integrated circuit, the method comprising: depositing a sacrificial layer, (Figure 2B #42 & Paragraph 0023 Lines 5-6), overlying a metallization level, (Figure 2B #41a); forming an opening, (Figure 2C area of #44 & Paragraph 0023 Lines 11-12), in the sacrificial layer, (Figure 2B #42 & Paragraph 0023 Lines 5-6); depositing a metal, (Figure 2B #43 & Paragraph 0023 Lines 14-17), in the opening, (Figure 2C area of #44 & Paragraph 0023 Lines 11-12), the metal, (Figure 2B #43 & Paragraph 0023 Lines 14-17), being coupled to an interconnect line in the metallization level, (Figure 41a); and etching the sacrificial layer, (Figure 2E and F #42 & Paragraph 0024 Lines 18-20), using a chemistry that includes a noble gas fluoride to create an air core, (Figure 2G the area under #46), overlying the metallization level, (Figure 2G #41a).
2. Referring to claim 2, a method further comprising the act of planarizing the metal prior to exposing the sacrificial layer, (Paragraph 0023 Lines 17-20).

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3. Referring to claim 3, a method further comprising the act of depositing a topside layer, (Figure 2E & F #46), overlying the air core, (Figure 2F the area above #41a & b).
4. Referring to claim 4, a method further comprising the act of depositing a capping layer, (Paragraph 0023 Lines 11-12, where it is inherent that a mask had to be deposited to create the opening in the sacrificial layer for #41a), overlying the sacrificial layer, (Figure 2B #42 & Paragraph 0023 Lines 5-6), prior to forming an opening in the sacrificial layer.
5. Referring to claim 5, a method, wherein the sacrificial layer, (Figure 2B #42 & Paragraph 0023 Lines 5-6), is deposited overlying a support layer, (Figure 2b #40).
6. Referring to claim 6, a method, wherein the opening includes a via, (Figure 2C #44).
7. Referring to claim 8, a method, wherein the noble gas fluoride includes xenon difluoride, (Paragraph 0024 Lines 18-20).
8. Referring to claim 9, a method, wherein the sacrificial layer, (Figure 1j #110, 120, 130, & 140), includes polycrystalline silicon, (Paragraph 0023 Lines 6-7 & Paragraph 0019 Lines 13-15).

***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1-11 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,555,467 Hsu et al. in view of U.S. Patent Application Publication No. 2003/0073302

Huibers.

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9. Referring to claim 1, a method of forming an interconnect line in an integrated circuit, the method comprising: depositing a sacrificial layer, (Hsu et al. Figures 9 & 12 #44), overlying a metallization level, (Hsu et al. Figures 9 & 12 #42); forming an opening, (Hsu et al. Figures 9 & 12 #60), in the sacrificial layer, (Hsu et al. Figures 9 & 12 #44); depositing a metal, (Hsu et al. Figures 10 & 12 #72), in the opening, (Hsu et al. Figures 9 & 12 #60), the metal, (Hsu et al. Figures 10 & 12 #72), being coupled to an interconnect line in the metallization level, (Hsu et al. Figures 10 & 12 #42); and etching the sacrificial layer, (Hsu et al. Figures 9 & 12 #44), using a chemistry that includes a noble gas fluoride, (See \*\* below), to create an air core, (Hsu et al. Figure 12 #100), overlying the metallization level, (Hsu et al. Figure 12 #42).

\*\* Hsu discloses forming the sacrificial layer with a sacrificial polymer. However, Huibers in the US Patent Application Publication US 2003/0073302 A1, discloses that sacrificial silicon has a better selectivity than other materials to the etchant gas (Paragraph 0028).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to form the sacrificial layer of Hsu with silicon, since ms taught by Huibers, sacrificial silicon has a better selectivity to the etchant gas.

Hsu further does not disclose removing the sacrificial layer in an environment including a noble gas fluoride.

In re claims 1-11, Hsu does not disclose wherein the noble gas fluoride includes xenon difluoride ( $\text{XeF}_2$ ), nor wherein the sacrificial layer includes polycrystalline silicon.

However, Hsu discloses, that the etching of a sacrificial silicon portion is as high as

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10000:1 compared to other materials (Paragraph 0028). Also, among the etchants that are used for the removal of sacrificial layers or regions in both isotropic in and anisotropic etching procedures are noble gas fluorides and halogen fluorides.

These materials, used in the gas phase, selectively etch silicon relative to other materials such as silicon-containing compounds, metallic elements and compounds of metallic elements. The selectivity is not infinite, however, and can vary widely with the equipment, process, materials and reaction conditions. XeF<sub>2</sub>, for example, has demonstrated selectivities as high as 400:1 to 500:1, but any improvement in this ratio would significantly benefit the cost and reliability of the products manufactured (Huibers Paragraph 0027).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have as sacrificial layer in the invention of Hsu a polycrystalline silicon layer and etch it with XeF<sub>2</sub> as taught by Huibers, since, the etching of a sacrificial silicon portion by the use of etchant gases that are noble gas fluorides or halogen fluorides is performed with greater selectivity toward the silicon portion relative to other portions of the device by the addition of non-etchant gaseous additives to the etchant gas. Also, among the etchants that are used for the removal of sacrificial layers or regions in both isotropic in and anisotropic etching procedures are noble gas fluorides and halogen fluorides. These materials, used in the gas phase, selectively etch silicon relative to other materials such as silicon-containing compounds, metallic elements and compounds of metallic elements. The selectivity is not infinite, however, and can vary widely with the equipment, process, materials and reaction conditions. XeF<sub>2</sub>, for example, has demonstrated selectivities as high as 400:1 to 500:1, but any improvement in this ratio would significantly benefit the cost and reliability of the products manufactured.

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10. Referring to claim 2, a method further comprising the act of planarizing the metal prior to exposing the sacrificial layer, (Hsu et al. Col. 4 Lines 45-46).
11. Referring to claim 3, a method further comprising the act of depositing a topside layer, (Hsu et al. Figure 12 #82), overlying the air core, (Figure 12 #100).
12. Referring to claim 4, a method further comprising the act of depositing a capping layer, (Hsu et al. Figures 9 & 12 #50), overlying the sacrificial layer, (Hsu et al. Figures 9 & 12 #44), prior to forming an opening in the sacrificial layer.
14. Referring to claim 5, a method, wherein the sacrificial layer, (Hsu et al. Figures 9 & 12 #44), is deposited overlying a support layer, (Hsu et al. Figures 9 & 12 #18).
15. Referring to claim 6, a method, wherein the opening includes a via, (Hsu et al. Figures 9 & 12 #60).
16. Referring to claim 7, a method, wherein the metal includes copper, (Hsu et al. Figure 10 #72 and Col. 4 Lines 45-46).
17. Referring to claim 8, a method, wherein the noble gas fluoride includes xenon difluoride, (Huibers Paragraph 0027 and See \*\* above).
18. Referring to claim 9, a method, wherein the sacrificial layer, (Hsu et al. Figures 9 & 12 #44), includes polycrystalline silicon, (Huibers Paragraph 0028 and See \*\* above).
19. Referring to claim 10, a method, wherein the capping layer, (Hsu et al. Figures 9 & 12 #50), includes silicon nitride, (Hsu et al. Col. 4 Lines 4-5).
20. Referring to claim 11, a method, wherein the metallization level, (Hsu et al. Figures 9 & 12 #72), includes a damascene structure.

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***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Victor A Mandala Jr. whose telephone number is (571) 272-1918. The examiner can normally be reached on Monday through Thursday from 8am till 6pm..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nathan J Flynn can be reached on (571) 272-1915. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on accessing the PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

NATHAN J. FLYNN  
SUPERVISOR, Private PAIR  
TECHNOLOGY CENTER



VAMJ  
2/18/05